Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.7, 2018
www.iiste.org

Determination of Nitrogen and Phosherous Fertilizer Requirement for Sorghum (Sorghum Bicolor (L.) Production in Kersa- Jimma Zone of Ethiopia, East Africa

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Abstract
Sorghum (Sorghum bicolor (L.) Moench) is one of the cereals grown in the marginal areas of the world especially in many of parts of Ethiopia. Therefore, the afield experiment was carried out during the 2016/17 crop seasons at Karsa Woreda Jimma Zone to evaluate the response of various levels of nitrogen (N) and phosphorus (P) fertilizer using sorghum. The treatments consisted of factorial combinations of four rates each of N (0, 23, 46 and 69 kg N ha−1) and P (0, 11.5, 23 and 34.5 kg P ha−1) laid down in a randomized complete block design (RCBD) with three replications. The result showed there was a significant effect of on N rates on plant height, grain yield, 1000 grain weight, number of lower dried leaves and stem diameter. There was a significant effect of on P rates on days to 50% flowering, stem diameter, number of basal nod tiller and number of lower dried leaves. There was Significant ($P \leq 0.01$) interactions effect between NP for panicle length and number of spikelets. Highly significant and positive correlations of grain yield with yield components were observed mainly for leaf area index (r=0.46**), harvest index(r=0.61**), plant height (r=0.54**), number of head harvested (r=0.63*), head weight (r=0.71**) and biomass yield (r=0.35*). Generally, highest grain yield of 5994 kg $ha^{-1}$and value cost ratio of 6.28 was obtained from 46 N and 11.5 k/ha P ha-1and the lowest grain yield was recorded (4512 kg ha-1) from the check treatment. Therefore, it could be concluded that Aba-melko sorghum could be 46 N Kg ha-1applied under rain fed area to attain maximum yield and economic optimum rates.
Keywords: Nitrogen, phosphorous, Aba-melko, fertilizer rate, Grain yield.

1. Introduction

Sorghum [Sorghum bicolor (L.) Moench] is the fifth most important cereal after rice, wheat, maize and barley. Also the second major cereal crop next to teff in consumption in Ethiopia. It's is often referred to as "coarse grain" or "poor people's crops" because it is grain mainly consumed by the poor people Esele (1992). In Ethiopia, Sorghum accounts for one-third of the total cereal crops production area and accounted for about 16.36% (47,520,956.04 quintals) of the total cultivated area in Ethiopia in 2016/17 (2009 E.C.) of the grain production in the same order and the CSA (2017).

Ethiopian national average yield was 25.25 q/ha. The limited use of modern inputs is a major characteristic of crop production in Ethiopia and it seems to be a major explanation for its current low productivity. Sorghum constitutes a major staple crop in the arid areas of Ethiopia schnider and Anderson, (2010) the average under sorghum cultivation is estimated to be 1.5 million ha per year Demeke and marcantoni, (2013) much of the area under production lies in the northern central highlands of the country.

Balanced fertilizer use, along with complementary use of organic and bio-sources can help reverse environmental degradation by providing much needed nutrients to the soil, thereby increasing crop yields. (Shrotriya 1998) reported that balanced application of NPK caused an increase in sorghum yield up to 122 % in India. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of Sorghum. Fertilizer is very important input for intensive production the profitability of Sorghum production systems depends on yield and input quantities. So the appropriate fertilizer input that is not only for getting high grain yield but also for attaining maximum pro-fertility.

Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle. The presence of n in excess promotes the development of the above ground organs with abundant dark green (high chlorophyll) tissues of soft consistency and relatively poor root growth. This increases the risk of lodging and reduces the plant's resistance to brash climatic condition and foliar diseases. Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage. Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important Alinajoati sisie & Mirshekari, (2011). Phosphorus is a major component in ATP, the molecule that provides "energy" to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration.

2. Materials and methods

2.1. Description of the Study Area

The current field experiment was conducted at karsa woreda zone of Ethiopia. To determination of nitrogen and phosherous fertilizer requirement for sorghum production in Jimma zone and their relative economics in sorghum during the main cropping season of 2016. The site is located at about 28 km east of Jimma town and 7° 40′ 0″ N latitude and 36° 50′ 0″ E longitude at an average elevation of 1740 to 2660 m amsl and average maximum and minimum temperature is 28.80C and 11.8 0C respectively and reliably receives good rains, ranging from 1,200 – 2,800 mm per annum cropping season.

2.2. Description of the experimental materials

Plant materials: In the present study, Sorghum varieties Abamelko which adapted to the agro-ecology of the area were used. Varieties Abamelko is the most promising released by Jimma Agricultural Research Centre. It has wider adaptability and grows well at altitudes ranging from 1740 to 2660 meters above sea level with an annual rainfall of 1,200 – 2,800 mm.

2.3. Experimental design and plot management

The experimental field was ploughed and harrowed by a tractor to get a fine seedbed and leveled manually before the field layout was made. Sowing was done on June 6, 2016, and the seeds were sown at a spacing of 75 cm between rows and 25 cm between plants. The nitrogen fertilizer source used was urea (46% N) which was applied by drilling in two splits and the remaining half at knee high stage along the rows of each plot to ensure that N is uniformly distributed. The treatments comprising a factorial combination of four N rates (0, 23, 46, and 92kg N ha and three P rates (0, 12.5, 23 and 34,) and were arranged in a Randomized Block Design with three replications. The plot size was 3.6 m long and 4.5 m wide that could accommodate 6 rows. The four rows in the net plot were set aside for data collection to eliminate any border effects. Phosphorus fertilizer in the form of Triple-super phosphate (TSP) was applied by drilling in the rows at the time of sowing and incorporated into the soil before seeding and the remaining half of nitrogen was applied seven weeks after emergence of emergency. Weeds were controlled by one hand hoe at two weeks after emergence and followed by twice hand weeding hoeing to avoid competition with the sorghum plants for the N applied. Sorghum plants in the l net plot area ($10.80m^2$) were harvested at normal physiological maturity. The ear heads in each plot were harvested manually and were separately threshed.

2.4. Data Collection and Measurement

2.4.1. Days to 50% flowering: The number of days from sowing until the date on which 50% of the panicles flowered per plot.
2.4.2. Days to 90% physiological maturity: Days to 90% physiological maturity was taken when 90% of the plants in the plot formed a black layer on the sorghum head.
2.4.3. Plant height: Plant height (cm) was recorded on five random plants at maturity by measuring the height from the ground to the tip of the panicle.
2.4.4. Numbers of lower dried leaves: Numbers of lower dried leaves were counted and the average value of 5 randomly taken plants was determined.
2.4.5. Stem Diameter (girth): Stem Diameter was measured and the average value of 5 randomly taken plants stem 5cm above ground.
2.4.6. Leaf area: Leaf area per plant, sample leaves were taken from the lower, middle and upper part of the sampled plants and determined by using the method developed by Sticker LA = L x W x 0.75
Where: LA = Leaf Area; L = Leaf Length; W = Maximum Width of the leaf; 0.75 = Constant or correction factor for sorghum.
The leaf area index was also calculated as the ratio of the leaf area to the respective area of land occupied by the plant.
et al. (1961) as:
2.4.7. Lodging: Lodging was recorded at the time of harvest from four net plot rows.
2.4.8. Thousand seeds weight: Thousand seeds of sorghum were counted and weighed (g) using sensitive balance from the bulk of the seeds of sorghum and adjusted to 12.5% moisture level.
2.4.9. The number of panicles/plant: The number of panicles/plant was also recorded from five pre-tagged randomly selected plants.
2.4.10. The number of effective tillers/plant: The number of effective tillers/plant was counted at physiological maturity.
2.4.11. Biomass yield: Five pre-tagged randomly selected plants were considered for determination of above ground dry biomass weight by drying in sunlight for ten days till a constant dry weight was attained
2.4.12. Grain yield: Grain yield (q/ha) was recorded after harvesting from the central four rows of the net plot of

3 m × 3.6 m=10.80m2. Seed yield was adjusted to 12.5% moisture using moisture tester (Dickey-john) and converted to quintal ha-1 for statistical analysis.
Adjusted yield=Actual yield × 100-M/100-D; where
M is the measured moisture content in grain and D is the designated moisture content (12.5%).

2.4.13. Harvest index: Harvest index was calculated as: HI (%)=Sy/by × 100;
where HI is harvest index, SY is seed yield and BY is above ground dry biological yield.
D is the designated moisture

2.4.14. Soil sampling and analysis: Soil samples were collected prior to planting and after harvesting from a depth of 0-30 cm in a zigzag pattern randomly from the experimental field using soil auger. Composite samples were prepared for analysis to determine the soil physicochemical properties of the experimental site at Jimma agricultural research center plant tissue and Soil Laboratory. The composited soil samples were air-dried, ground and sieved to pass through a 2 mm sieve. Total nitrogen was determined following Kjeldahl procedure, the soil pH (in water suspension) by a digital pH meter Page AL (1982), organic carbon by wet digestion method Walkley A, Black CA (1934), available phosphorous by Olsen method, Cation exchange capacity (CEC) by ammonium acetate method (Cottenie A 1980), and soil texture by Bouyoucons Hydrometer method Bouyoucos GJ (1962).

2.4.15. Economic analysis

Economic analysis was made following CIMMYT methodology (CIMMYT, 1988). The cost of 100 kg urea (2608 birr), 100 kg TSP (6304 birr) and sorghum grain price of 442 birr per 100 kg were used for the benefit: the cost analysis. The analysis of data in relation to different factors of production under test viz; N and P fertilizer rates were computed in terms of: 1.Gross return (Birr ha-1) from total economic production and by-products obtained from the crops included in the cropping system are calculated based on the local market prices at harvest, 2.Net return (Birr ha)=(Gross return – Cost of Production), 3.Cost of Production (Birr ha-1), 4. Benefit: Cost ratio (Gross return/Cost of Production), 5.Per day Productivity (kg ha-1), (Grain Yield/Crop duration), 6. Return/Birr Investment (Net return/ Production Cost) were determined and 7. The undominated treatments were ranked from the lowest to the highest cost. For each pair of ranked treatments, the percent marginal rate of return (MRR) was calculated. The MRR (%) between any pair of undominated treatments was the return per unit of investment in fertilizer. To obtain an estimate of these returns the MRR (%) was calculated as changes in NB divided by changes in cost. Thus, a MRR of 100% was used indicating for every one EtB expended there is a return of one EtB for a given variable input.

2.4.16. Statistical analysis

The data were subjected to analysis of variance by SAS software. Significance of differences between samples was separated using the least significance difference (LSD) at 5% level of significance.

3. Results and Discussion

3.1. Phenological and Growth parameters

3.1.1. Days to 50% Flowering

The statistical analysis indicates that phosphorous significantly affect ($p < 0.05$) days to 50% flowering at P 0 kg/ha^{-1} took longer flowering dates of 104 days as compared to P 34.5 kg ha^{-1} that took 101 days (Table-2). On the other hand increases in nitrogen, rate fastens days to 50% flowering. This might be due synergetic effects of both that helped more efficient use of available phosphorous and it has positive effect 50% flowering that resulted in a minimum number of days or early to 50% flowering. Similarly, Das et al., (1996) observed that response of Sorghum to P was strongly influenced by soil P status as well as applied P level and was similar at three physiological stages of crop growth mainly at boot leaf initiation, 50 percent flowering and maturity.

3.1.2. Number of Basal Node Tiller

The interaction effect of nitrogen and phosphorous was statistically not on a number of basal node tiller but phosphorous had a significant effect on this parameter. The maximum number of basal node tiller (33) was produced from control (0 P kg ha^{-1}) and the minimum (18) was produced at (23 P kg ha^{-1}) (Table 2). and there was amazingly significant decrement with an increase in phosphorous rate that the decrease was found by 30% The reduction number of basal node tiller with higher prosperous rate might be due to sorghum least response to phosphorous fertilizer and also it's well known that sorghum grown under less fertile land have ability to produce maximum number of basal node tiller than those grow under fertile land. On contrary, the application increase in N rate did not affect basal tillering capacity but others finding suggested that it stimulated growth through greater tillering and head production.

3.1.3. Leaf Area Index (LAI)

There were not main factor effect of nitrogen and phosphorous rates on leaf area index (Table 3 and 4) respectively. Even though, both nitrogen and phosphorous rates were not significantly interacted to influence this parameter there were increase in LAI was possibly due to the improved leaf expansion in plants through application of optimum nitrogenous fertilizers. The highest LAI (0.275 cm^2 at 46 N kg ha^{-1} and 0.268 cm^2 at 23 P kg ha^{-1}) was recorded, while the lowest (0.246 cm2 at 0 N kg ha^{-1} and 0.261 cm^2 at 0 P) were recorded. Generally, an increasing trend in LAI was observed with increased N and P application rates. The Similar to this finding, Haghighi et al. (2010) reported an increasing trend in LAI in maize due to an increase in N fertilizer application rates

3.1.4. Stem Diameter (Stem girth)

The result of stem diameter (Girth) was highly significant effect (P <0.01) of the phosphorous and similar effect of N was observed but with no interaction. The lowest girth lowest (0.85 cm) was obtained from control (0 kg Pha^{-1}) the highest was recorded from 46 kg N and 34.5 kg P that both gave the same value of 1.00 cm (Table 3). This result revealed that with increased nitrogen and phosphorous rates there was an increase stem diameter up to (34.5 kg P ha^{-1}) but start to decrease after (46 kg N ha^{-1}). An increase in P application seems to affect more girth diameter than did N application. Similarly, Khalid et al (2003) reported that increases in plant height, stem diameter and number of leaves per plant, and he further observed an increase in fodder yield at higher fertilizer application rates.

3.1.5. Number of Lower Dried Leaves

The statistical analysis indicates that Nitrogen significantly affect (p <0.05) lower dried leaves drying up when sorghum was at graining filling period that both N and P application significantly affected number of lower dried leaves that 46 kg N and 34.5 kg P gave the maximum Number of Lower Dried leaves (5 leaves) but start to decrease after (46 kg N ha^{-1}). (Table 2 and 3). This result revealed that with increased nitrogen and phosphorous rates there was an increase Number of Lower Dried leaves up to (34.5 kg P ha^{-1}) but start to decrease after (46 kg N ha^{-1}). An increase in P application seems to affect more Number of Lower Dried leaves than did N application. These findings in agreement with Richards, (1997). However as the levels of both N and P increases the response starts to decline which probably indicates some acidification of the soil resulting in fixation of P Abdullah et al. (2000) also reported that total yield of green forage increased with the increasing level of P fertilizer and Khalid, et al. (2003). Similarly Khot et al. (1997) that both authors reported a total yield of green forage increased with the increasing level of P fertilizer. Later on Khalid, et al. (2003) reported two sorghum cultivars had increasing forage yield as NP rates raised.

3.1.6. Plant Height

Taller plant heights from increasing application levels of N fertilizer were recorded and significant response to N application was detected. (Table 3). At 46 kg ha^{-1} N and 11.5 kg/ha^{-1} P the tallest plant height of 164.08 cm was recorded and beyond 46 kg N ha^{-1} it was started to decrease and the shortest plant height 146.0 cm was produced from the treatment combination of 0 kg N and 23 kg ha^{-1} P (Table 3). The remarkable nitrogen effect on plant growth might be due to early take up that made the plant competent enough for sunlight energy use efficient and make photosynthesis and fastest in use of water and other resources. The current result corroborates the finding of G.B. Ashiono et Al., (2005) who reported that plant height increased up to 46kg ha^{-1} then decreased gradually at highest N levels The application of phosphorus fertilizer gradually increased plant height, stem diameter, number of leaves per plant, leaf area per plant and fodder yield (Table 3). Previous reports of P. R. S. Roy (2010) also showed that plant height was gradually increased with increasing level of phosphorus up to 40 kg P ha^{-1} and then beyond it plant height was not further increased with application of phosphorus fertilizer.

3.2. Yield and Yield Related Variables

3.2.1 Panicle Length

Due to panicle length, a significant interaction between nitrogen and phosphorous was observed. (p <0.01). At (69N and 11.5 P kg ha^{-1}) the longest panicle length was that gave 32.00 cm. and the control treatment (0 N and 0 P kgha^{-1}) had the shortest panicle length of 26.33 cm (Table 4). The result further justified that panicle length increased up to (23 N kg ha^{-1})and then started to decline with increasing nitrogen rate and due to P, it was increased up to (11.5 kg ha^{-1})and then after decreased that might be due to attributes of some genetic effects of Abamelko that it is found shorter in all growth characters. The present results are in agreement with the findings of Wondimu et al (2013) who reported that yield components such as panicle length, panicle weight plant seed weight panicle^{-1}, seed number panicle^{-1} and 1000-seed weight were affected by the main effects of nitrogen fertilizer.

3.2.2. Number of Spikelet per head

The number of spikelets per head had significant interaction between nitrogen and phosphorous rates. The maximum numbers of five spikelets per head were recorded at treatment combination of (69N and 11.5P kg ha^{-1} and 46N and 23 P kg ha^{-1}) and the minimum number of four was recorded from (0 N and 0 P kg ha^{-1}) (Table 5). This might be due to the synergetic effects of NP fertilizer rates. The current result corroborates the finding of Jeremy L (2007) found that time of nitrogen application had significant effect on sorghum yield attributes.

3.2.3. Thousand- Grain Weight

The statistical analysis on thousand grain weight was significant response to nitrogen (P <0.05). The highest thousand grain weight (2.49 g) produced from (0 N kg ha^{-1}) while the minimum was (2.25g) recorded from the highest nitrogen rate (69 N kg ha^{-1}) (Table 5). The effect was statistically not significant between (23 and 46 N kg ha^{-1}) (Table 10). There is a decrease in thousand grain weights with an increase in nitrogen rate the current result is in agreement with Wondimu et al., (20013) who reported that thousand seed weight responded negatively to nitrogen fertilization at Sirinka.

3.2.4 Biological yield

The results of the analysis of variance showed that biological yield (BY) of sorghum were significantly influenced by the main effect of nitrogen (Table 6). Biological yield (BY) is a function of photosynthetic rate and proportion of the assimilatory surface area. The highest (6336.2 kg ha^{-1}) biological yield was recorded at 23 N kg ha^{-1} but the smallest (5146.2 kg ha^{-1}) was recorded at the highest 69 kg ha^{-1} N kg ha^{-1} with the increase in the rate of nitrogen application biological yield increased significantly up to 23 N kg ha^{-1}. The increase in biological yield with increase in rate of N might be due to better crop growth rate, LAI and accumulation of photo assimilate due to maximum days to maturity by the crop, which ultimately produced more biological yield. The result was in agreement with Haftom et al (2009) the application of the highest level of N resulted in less biomass yield compared to 92 kg N ha-1.

3.2.5 Harvest index

The interaction effect of nitrogen and Phosphorous rates on harvest index was not significant but the effect of nitrogen rates on harvest index was significant (Table 6). The highest (30.47) harvest index was recorded at 0 kg ha^{-1} but with the increase in the rate of nitrogen application, harvest index increased significantly up to 46 N kg ha^{-1}. The result was in agreement with Abdo W (2009) reported highest harvest index from treatments with the lowest rate of nitrogen application also Lawrence *et al* (2008) reported that harvest index in maize increases when nitrogen rates increased.

3.2.6. Grain Yield

The statistical analysis on grain Yield was significant response to nitrogen ($P <0.05$). (Table 6) result revealed significant response to nitrogen. At 46 N kg ha^{-1} highest grain yield of (5994 kg ha^{-1}) was and it was followed by (23 kg ha^{-1} N) that gave (5460 kg ha^{-1}). It has been theoretically proven that N fertilizer improves plant growth, and as a result of enhanced photo assimilates to the stage of grain development, grain production and causes an increment of the biological yield. Increased grain yield was possibly due to an increase in nitrogen uptake and balanced N and P in the soil after N application up to pick requirement (46 kg h^{-1}) (fig-1), it may be due to an enhanced number of grains panicle-1 and 100-grain weight and a number of spikelets. Also, this might have occurred due to the higher better response of Abamelko to N levels that resulted in higher grain yield. The current result is in agreement he results of this study are consistent with result of Sage and Pearcy who reported that a well-balanced supply of N results in higher net assimilation rate and increased grain yield as also found by Al-Abdulsalam MA (1997). Corroborating the results of this study, Blankenau et al. (2002) stated that proper rate and time of N application are critical for meeting crop needs, and considerable opportunities exist for yield improvement.

3.3. Economic Analysis

The result of the economic analysis (partial budget) for fertilizers N and P rates are presented in (Table 6). Increasing order of total costs at varying the fertilizer N and P fertilizer combinations 0/0, 0/11.5, 0/23, 0/34.5, 23/0, 23/11.5, 23/23, 23/34.5, 46/0, 46/11.5, 46/23, 46/34.5, 69/0, 69/11.5, 69/23 and 69/34.5 N P kg ha^{-1} had shown increment in gross benefits. That was found in ranges from 12579.32 to 26493.48ETB. In general, 46/11.5 N P kg ha^{-1} gave highest gross field benefit whereas the 69/0 N P kg ha^{-1} gave the lowest. When compared to 46/11.5 N P kg ha^{-1} all treatments combination except 0/0,0/11.5,0/23, 23/11.5, 46/0 and 69/0 N P kg ha^{-1} has a total variable cost (table-6). The marginal rate of return (MRR) of most treatment was found greater than 100% at 46 kg/ha N and 11.5 P kg ha^{-1}, the highest MRR of 281.28% was attained. At these rates of NP fertilizer higher value cost ratio of 6.28 was recorded that indicates for one ETB invested the return was 6.28 ETB. It was in agreement with the report of Shahzad. J et al., (2010) showed that as N increased from 40 kg to 80 kg rain yield was increased, but there was no economic benefit. Thus, maximum economic grain yields for sorghum occurred at fertilizer treatment combination 46/11.5 NP kg ha^{-1}. As a guiding rule, more than 100% MMR is considered as an acceptable economic benefit to farmers CIMMYT, (1988). This is because such a return would offset the cost of capital (interest) and other related transaction costs gave an attractive profit marginal to sever as an incentive. Thus, the change from farmers' practice (no fertilizer) to the application of 46/11.5 NP kg ha^{-1} could be profitable and promise for better sorghum production in farmers field of the Karsa wareda in Jimma Zone.

SUMMARY CONCLUSIONS

Some yield components such as leaf area index, biomass yield, number of head harvested and head weight were not significantly affected nitrogen and phosphorous fertilizer rates. On the other hand most measured parameters such as plant height, grain yield, thousand grain weights, days to 50% flowering; number of basal nod tiller, stem diameter and number of fired leaves had a significant response to NP fertilizers. The analysis of variance indicated that there were positive interaction effects of nitrogen and phosphorous fertilizer rates on panicle length and number of spikelets. Therefore, the experimental results indicated that interaction of nitrogen and phosphorous fertilizer rates had a significant effect on growth, yield and yield components. It was further noted that a number of the head harvested number was highly significant (P <0.01) and positively correlated with a number of basal node tiller, stand count at harvest, grain yield and biomass yield.

The economic analysis done showed that at 46 kg ha^{-1} N and 11.5 kg ha^{-1} P, the highest MRR of 281.28% was attained. At these rates of NP fertilizer higher value cost ratio of 6.28 was recorded that indicates for one ETB invested the return was 6.28 ETB. Therefore, a change from farmers' practice (no fertilizer) to the application of 46/11.5N P kg ha^{-1}could be profitable and promise for better sorghum production in farmers field of the Karsa woreda in Jimma Zone and similar agroecology.

References

Abdo W (2009) Effect of different rates of nitrogen fertilizer on yield, yield related traits and quality of durum wheat (Triticum turgidum L. var. durum). Plant Soil 257: 205-217.

Abdullah, M., Yasin, M. and Qureshi, R. H. 2000. Interactive effects of phosphorus and soil salinity Availability of desorbed phosphorus and internal phosphorus requirement by Sorghum in an Alfisol. J. Indian Soc. Soil Sci., 44(3): 427 -433.

Al-Abdul Salam MA (1997) Influence of nitrogen fertilization rates and residual effect of organic manure rates on the growth and yield of wheat. Arab Gulf Journal of Science Research 15: 647-660.

Anderson A, 2009, the impact of tillage practices and crop residue (stubble) retention in the cropping system of Western Australia, Agriculture Authority, PP.99

Blankenau K, Olfs HW, Kuhlmann H (2002) Strategies to improve the use efficiency of mineral fertilizer nitrogen applied to winter wheat. Journal of Agronomy and Crop Sci 188: 146-154.

Borrell AK, Hammer GL and Douglas ACL. 2000a. Does Maintaining Green leaf area in sorghum improve yield under drought? I. Leaf Growth and Senescence. Crop Sci. 40: 1026-1037.

Bouyoucos GJ (1962) Hydrometer method improved for making particle size analysis. Agronomy journal 54: 464-465

Central Statistical Authority, Agricultural Sample Survey (2017) Report on the area and major production for major crops of Private peasant holdings. Addis Ababa, Ethiopia.

CIMMYT, 1988. From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico, DF

Cottenie A (1980) Soil and plant testing as a basis for fertilizer recommendations. FAO Soil Bulletin, Rome 38: 61-100.

Das, S. K., Sharma, K. L., Singh, B. R., Rao, B. R. C. P., Srinivas, K. and Reddy, M. N. 1996. Defoliation affects the dry matter accumulation and seed yield particularly by reducing the leaf area available for light interception and photosynthesis Polat et al., 2011. Polat,

Demeke M, Di Morcantonio F, 2013. Analysis of incentives and disincentives for sorghum in Ethiopia. Technical notes serious, MAFAP, FAO< Rome.

Esele, J.P. 1992, Folia and head diseases of sorghum. African Crop Science Journal 3:185-189.

G.B. Ashiono, T.E. Akuja1, S. Gatuiku & P. Mwangi 2005 Effects of nitrogen and phosphorus application on growth and yield of dual-purpose sorghum in the dry highlands of Kenya African Crop Science Conference Proceedings, Vol. 7. pp. 1149-1152

Haghighi BJ, Yarmahmodi Z, Alizadeh O (2010) Evaluation of the effects of biological fertilizer on physiological characteristics and yield and its components of corn (Zea mays L.) under drought stress. American Journal of Agricultural Biological Science 5: 189-193.

Jeremy L (2007) Nitrogen management for wheat protein and yield in the Esperance Port Zone. State of Western Australia, pp: 14-20

Khot, A. B., Yargattikar, A. T. and Patil, B. N. 1997. Effect of irrigation scheduling and phophorus levels on green forage yield of Lucerne. Indian J. Agron. , 42(3): 544-546. on the growth and ionic composition of kallar grass. Pakistan J. Agric. Res., 16(1): 53 -58.

Khot et al. 1997 reported that the green forage yield increased significantly with increasing levels of P fertilizer.

Lawrence JR, Ketterings QM, Cherney JH (2008) Effect of nitrogen application on yield and quality of corn. Agronomy Journal 100: 73-79.Khalid, et al. 2003. Reported that, Effect of nitrogen and phosphorus on the fodder yield and quality of two Sorghum cultivars (Sorghum bicolor L.). Int. J. Agri. Biol., 5(1): 6 1 -63.

Page AL (1982) Methods of soil analysis- part two. Chemical and microbiological properties. American Society of Agronomy 3: 128-133.

Richard, M. 1997. Research Projects. Land and Water.

SAS (Statistical Analysis System) Institute Inc. SAS/STAT 9.2 User's guide. Cary, NC, SAS Institute, USA,

2008.
Schneider K and Anderson L 2010. Yield gap and productivity potential in Ethiopia agriculture: staple grains and pulses. EPAR Brif no 98. University of Washington, PP 24
Shahzad Jamaati-e-Somarin, Roghayyeh Zabihi-e-Mahmoodabad, Asgar Yari, Majid Khayatnezhad and Roza Gholamin, 2010. Study of Agronomical Nitrogen Use Efficiency of Durum Wheat, Affected by Nitrogen Fertilizer and Plant Density. ISSN 1818-4952 Shah, H., Sharif, M., Majid, A., Hayat, U. and Munawar, A. 2009.
Sheleme Kaba Shamme, Cherukuri V Raghavaiah*, Tesfaye Balemi and Ibrahim Hamza 92016) Sorghum (*Sorghum bicolor* L.) Growth, Productivity, Nitrogen Removal, N- Use Efficiencies and Economics in Relation to Genotypes and Nitrogen Nutrition in Kellem- Wollega Zone of Ethiopia, East Africa
Shrotriya, G.C. 1998. Balanced fertilization–Indian experience. Proc. Symp. Plant Nutrition Management for Sustainable Agriculture Growth. NFDC, Islamabad
S P. R. S. Royand Z. H. Khandaker.Effect of phosphorus fertilizer on yield and Nutritional value of sorghum (sorghum bicolor) Fodder at three cutting 2010, 39(1&2): 106 – 115 ISSN 0003 -3588.
Windom Bayu a, N. F.G. Rethman a & P. S. Hammes a15 Jan 2013. Growth and yield compensation in sorghum (Sorghum bicolor L. Moench) as a function of planting density and nitrogen fertilizer in semi-arid areas of northeastern Ethiopia
Walkley A, Black CA (1934) An examination of Digestion of Degrjareff Method for Determining Soil Organic Matter and Proposed Modification of the Chromic Acid Titration Method. Soil Science 37: 29-38.

Table 1: Effect of Phosphorous on Days to Flowering and Number of Basal Node Tiller P_2O_5 level

P_2O_5 level Kg ha^{-1}	Leaf area index	Days to 50% flowering	Stem diameter (Girth)	Number of basal node tiller	Number of Lower Dried Leaves
34.5	0.265	101.41b	1.0b	19.33b	5.01a
23	0.268	101.50b	0.96a	18.50b	4.80a
11.5	0.262	102.83ab	0.98a	23.66ab	4.90a
0	0.261	104.08a	0.85b	33.00a	4.28b
Mean	0.264	102.46	0.95	23.62	4.75
Cv (%)	2.04	12.09	9.79	18.93	9.78

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 2: Effect of Phosphorous (P_2O_5) on Stem Diameter (Girth), Leaf area Index, Lower Dried Leaves and Plant Height

Nitrogen level Kg ha^{-1}	Leaf area index	Number of Lower Dried Leaves	Stam diameter (Girth) in (cm)	Plant height (cm)
69	0.273	4.81a	0.96a	163.25a
46	0.275	5.06a	1.01a	164.08 a
23	0.263	4.71ab	0.94 ab	157.91 a
0	0.246	4.40b	0.88b	146.00 a
Mean		4.73	0.95	157.81
Cv (%)	15	2.04	9.79	7.32

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 3: Interaction Effect of Rates of N and P Fertilizers on Sorghum Panicle Length (Cm)

Levels of P (kg/ha^{-1})	Levels of N (kg/ha^{-1})			
	0	23	46	69
0	26.33i	28.77de	28.22def	27.17ghi
11.5	29.00d	29.00d	27.83efg	32.00a
23	27.78fg	28.33def	30.17b	30.00bc
34.5	29.17cd	27.44egh	26.77hi	27.67fgh
Mean	28.07	28.39	28.25	29.21
Cv %	2.01			

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 4: Interaction Effect of N and P Fertilizers Rates on Sorghum Number of Spikelets per head

Levels of P (kg ha^{-1})	Levels of N (kg ha^{-1})			
	0	23	46	69
0	4.39i	4.79de	4.70def	4.53ghi
11.5	4.83d	4.83d	4.64efg	5.33a
23	4.63sfg	4.72def	5.03b	5.00bc
34.5	4.86cd	4.57fgh	4.46hi	4.61fgh
Mean	4.68	4.73	4.7	49
Cv (%)	2.02			

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 5: Effect of Nitrogen on Thousand Grain Weights and Grain Yield Nitrogen level

Nitrogen level (Kg ha^{-1})	Biomass Yield (Kg ha^{-1})	Harvest Index	Thousand grain weight(gm)	Grain yield (kg)
0	5363.6ab	30.47ab	24.52^{a}	4512b
23	6336.2a	28.82b	23.89a	5460ab
46	5317.3ab	39.34a	23.25^{ab}	5994a
69	5146.5b	32.01ab	22.50b	4953ab
Mean	5540	32.66	23.54	5229.75
Cv (%)	21.29	22.68	6.56	20.48

Values followed by the same letter within a column are not significantly different at P< 0.05.

Table 6: Partial Budget Estimate with Net Benefit for Application of N and P Fertilizer Rates at Current Prices

Fertilizer levels	**Adjusted yield qt/ha**	***GFB* (EtB)**	**CU (EtB)**	**CTSP (EtB)**	**FAC (EtB)**	***TCV* (EtB)**	***NB* (EtB)**	**MRR (EtB)**	**VCR (EtB)**
0/0	15.12	6683.04	0	0	0	0	6683.04		
0/11.5	13.73	6068.66	0	725	12	737	5331.66	-183.36	7.23
0/23	15.59	6890.78	0	1450	12	1462	5428.78	-85.79	3.71
0/34.5	15.74	6957.08	0	2175	18	2193	4764.08	-87.50	2.17
23/0	19.75	8729.50	600	0	12	612	8117.5	234.39	13.26
23/11.5	17.59	7774.78	600	725	12	1337	6437.78	-18.34	4.82
23/23	18.52	8185.84	600	1450	18	2068	6117.84	-27.33	2.96
23/34.5	16.98	7505.16	600	2175	18	2793	4712.16	-70.56	1.69
46/0	17.44	7708.48	1200	0	12	1212	6496.48	-15.39	5.36
46/11.5	24.38	10775.96	1200	725	18	1943	8832.96	110.65	4.55
46/23	18.83	8322.86	1200	1450	18	2668	5654.86	-38.54	2.12
46/34.5	19.29	8526.18	1200	2175	24	3399	5127.18	-45.77	1.51
69/0	13.89	6139.38	1800	0	18	1818	4321.38	-129.90	2.38
69/11.5	17.28	7637.76	1800	725	18	2543	5094.76	-62.46	2.00
69/23	17.90	7911.80	1800	1450	24	3274	4637.8	-62.47	1.42
23/34.5	16.98	7505.16	1800	2175	24	3999	3506.16	-79.44	0.88

GFB = Gross field benefit; TCV = Total cost that varied; MMR= Marginal Rate of Return; NB = Net benefit; VCR= Value Cost Ratio; CU = Cost of urea Birr 26.08 per kg; CTSP =Cost of Triple-super phosphate Birr 63.04 per kg; FAC = Fertilizer application cost; EtB = Ethiopian Birr; Wage rate = Birr 12 per day; Labor to apply fertilizer per ha = 4 man-day; L Retail price of grain = Birr 442 per qt.

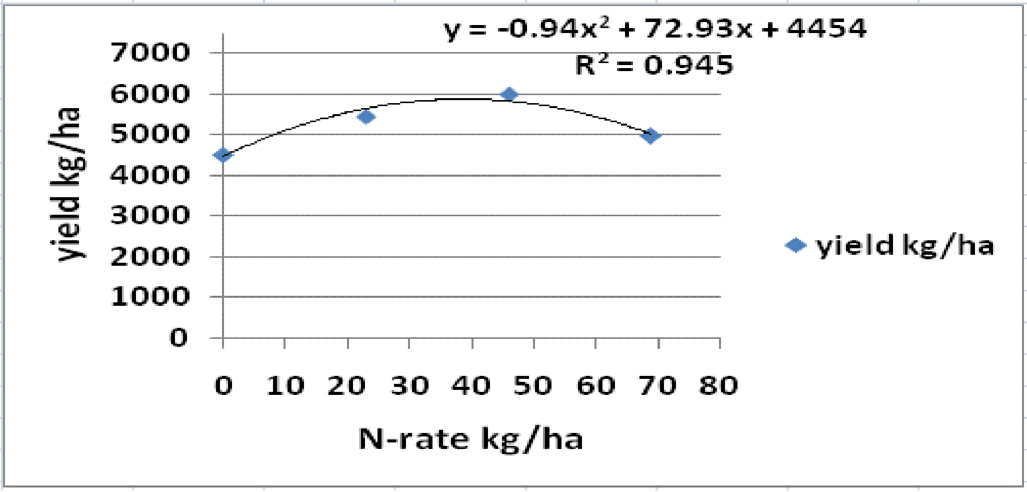

Figure 1: Sorghum Grain Yield Response Curve to Nitrogen.